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National Aerospace Laboratory NLR

AMS Tracker Thermal Control Subsystem

Condenser heaters installation procedure

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Document change log

Change Ref.	*Section(s)*	*Issue draft*
-	All	Initial issue

Change Ref.	*Section(s)*	*Issue draft 3*
	7.0	Comments on heaters under strain relief installation
	7.2	Deleted spot gluing on liquid line foil heaters; only spot gluing on the heater cables
	7.3	Deleted spot gluing for heaters under the strain relief side; the spot gluing of the wire will be done at the final step.

Change Ref.	*Section(s)*	*Issue draft 4*
	3.0	Updated manufacturing sequence
	7.0	Updated procedure sheets with picture and gluing details
	9.0	Added appendix B with drawing to position the foil heaters

Change Ref.	*Section(s)*	*Issue draft 4*
		Added appendix B with drawing to position the foil heaters

Change Ref.	*Section(s)*	*Issue draft 5*
	7.5	Added wire heater installation procedure

Summary

This document presents the process for the installation of self-adhesive heater on QM and FM condensers. The heater installation step is part of the overall production of the condensers.

Contents

(43 pages in total)

1 Scope of the document and test objective

The procedure in this document describes the installation of :

- Liquid line wire heaters
- Inlet/outlet foil heaters
- Condenser foil heaters

on QM and FM condensers.

The objective of the installation of this thermal components is to defrost the TTCS CO2 condenser lines after an AMS complete power down (liquid line heaters and condenser foil heaters), and to compensate the heat leak from the liquid lines into the cold condenser at freezing (inlet/outlet foil heaters)

2 References documents

	Title	Number	Date
RD-1	QM-FM Condenser gluing procedure	AMSTR-NLR-PR-038	December 2008
RD-2	TCS Tracker Radiator Panel Heater Installation	TCS-071219	January 2008
RD-3	TTCS Heater Specifications	AMSTR-NLR-TN-043-issue 1.5	July 2007

3 Condenser integration sequence

The heater installation step is part of the overall condenser manufacturing sequence. The bold lines indicate the steps described in this procedure. **(For the most update version of the sequence see RD-1).**
QM and FM condenser will undergo two different heater installation sequence.

1. Bend individual tubes
2. Label tubes
3. He leak test for individual tubes AMSTR-NLR-PR-040
4. Cut tubes to exact length according to the cutting procedure AMSTR-NLR-PR-008-v.2. QM-FM Condenser cutting procedure (to be approved)
5. Clean tubes inside & outside and seal the end: AMSTR_NLR-039 (to be approved)
6. Manufacture brazing plates
7. Apply stop off agent on brazing component AMSTR-NLR-041
8. Manufacture bottom, top plates and strain relieves in AL 2024 T351
9. Convert to AL 2024 T851 (worksheet by AIDC)
10. Manufacture manifold parts and filters
11. Clean manifold parts and filter AMSTR-NLR-039 (to be approved)
12. Perform nickel plating on tubes side to be brazed
13. Spot weld condenser tubes to manifold and apply solder around tubes
14. Braze tubes and manifolds AMSTR_NLR-041
15. He leak test on condenser tubing lay-out AMSTR-NLR -040
16. Proof pressure test up to 1.5 MDP = 1.5 * 160 = 240 bar AMSTR-NLR -040
17. **He leak on condenser tubing lay-out AMSTR-NLR –PR 040**

For QM condenser:

18. Install nutplates on top plate AMSTR-NLR-PR -38
19. Surface treatment of condenser plates and tube AMSTR-NLR-PR -38
20. Glue the condenser tubes to the base plate AMSTR-NLR-PR-38
21. **Glue foil heaters (under the strain relief side) over top plate AMSTR-NLR-PR-43**
22. Glue the top plate to the bottom plate and glue strain reliefs; AMSTR-NLR-PR-38
23. **Glue the remaining foil heaters on top plate; AMSTR-NLR-PR-043**
24. Clean outside tubes, manifold and condenser plates according to : AMSTR-NLR-PR.039 (to be approved)
25. Do a mass check/measurement on the condenser and condenser bolts

26. Fix condenser with bolts to transport jig AMSTR-NLR-PR-044-Condenser assembly to Transport and brazing jig (to be updated)
27. Perform thermal cycling test according TTCS-SYSU-TEST-TPR-013-3.0

For FM condensers:

18. Surface treatment of bottom plate and tube AMSTR-NLR-PR -38
19. Glue the tubes to the bottom plate AMSTR-NLR-PR-38
20. Surface treatment of top plate AMSTR-NLR-PR -38
21. Install nutplates on top plate
22. **Glue foil heaters (under the strain relief side) over the top plate AMSTR-NLR-PR-43**
23. Glue the top plate to the bottom plate
24. Surface treatment of top and bottom strain relief AMSTR-NLR-PR -38
25. Install nutplates on top strain relief
26. Glue strain reliefs; AMSTR-NLR-PR-38
27. **Glue the remaining foil heaters on top plate; AMSTR-NLR-PR-043**
28. Clean outside tubes, manifold and condenser plates according to : AMSTR-NLR-PR.039 (to be approved)
29. **Apply wire heater according to AMSTR-NLR-PR-043**
30. Do a mass check/measurement on the condenser and condenser bolts
31. Fix condenser with bolts to transport jig AMSTR-NLR-PR-044-Condenser assembly to Transport and brazing jig (to be updated)
32. Perform an outgoing inspection (visual and electrical) according to ATS N° (to be written)
33. Apply TS according to ATS N° (to be written)
34. Integrate the condenser to radiator according to ATS N° (to be written)

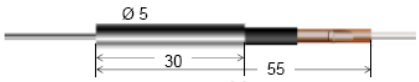
4 Detailed Heater descriptions

4.1 Liquid line wire heaters description

The liquid line wire heater are :

Thermocoax wire heaters:

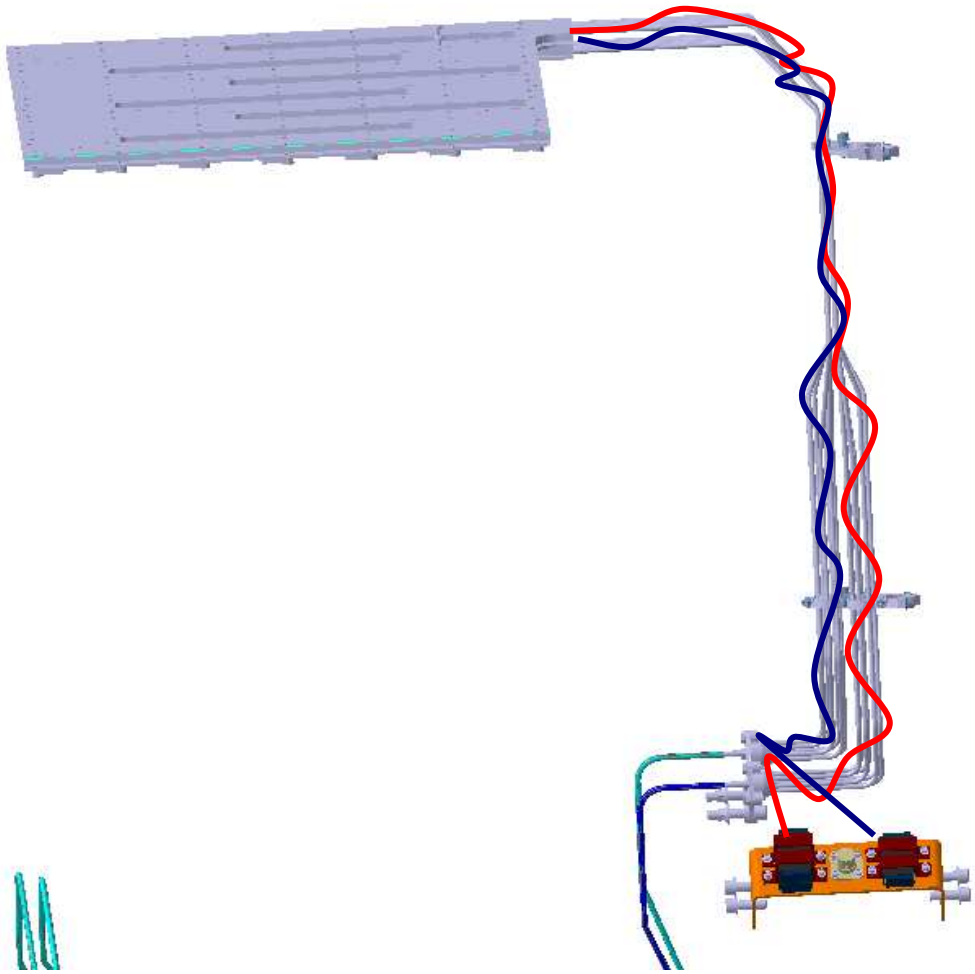
- **ZUZ : single core with cold ends**
- **Ac15 : austenitic stainless steel sheat**
- **Hot length:336cm +-10%**
- **Cold parts: 4cm**
- **Connector: CM15**

Plastic connection	Type Code	For heating element Ø (mm)	Max. working tempe-rature	Max. current (A)*	Power supply
CM 10 - 20 	CM 10 CM 15 CM 20	1 1.5 2	200°C	8 12 16	Cable : Length: 20 cm Section: 2 mm²

- **cement8**
- **E2219white wire**
- **200mm**
- 1.5 mm diameter 3,36 m long one with roughly 10 windings around the tubes

Option 1	**Heater type and spec**		**ZUZ/15/4-336-4/HcAc 12.4 Ohm/m**
	Heater wire selection line resistance [Ohm/m]		**12.4000**
	Cold end resistance [0.3 Ohm/m]	**[Ohm]**	**0.0240**
	Diameter wire	**[m]**	**0.0015**
	Calculated length	**[m]**	**3.3600**
	Calculated number of turns	**[-]**	**10.0000**

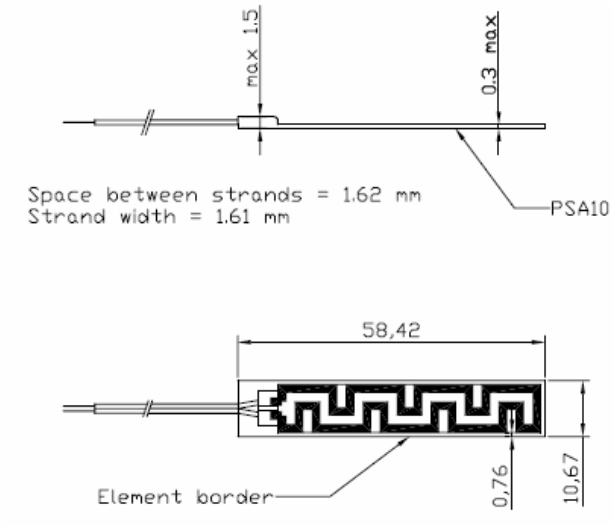
For each FM condenser 2 wire heaters are wrapped along the tubes from the condenser plate down to the manifolds: one side needs to be connected to the foil heater FHK 203 and the other side to the TB (as shown in the following picture). The connection to TB side will done at CERN.



4.2 Liquid line Inlet/outlet foil heaters description

The inlet/outlet foil heaters are Minco heater with the following description:

FHK203
Kapton Thermofoil heater
Dimensions 10.7 x 58.4 mm
R = 7.3 Ohm
Leads AWG-26, 760 mm long TF insulated
lead exit type #1
tested to NASA S-311-P-079 Table II
Foil Element Tophet A (non mangnetic)
PSA 10 backing



Each condenser will be equipped with two of them at the inlet/outlet position of the top plate as shown in the figure 4.1.The lead wire direction is described in the same figure.

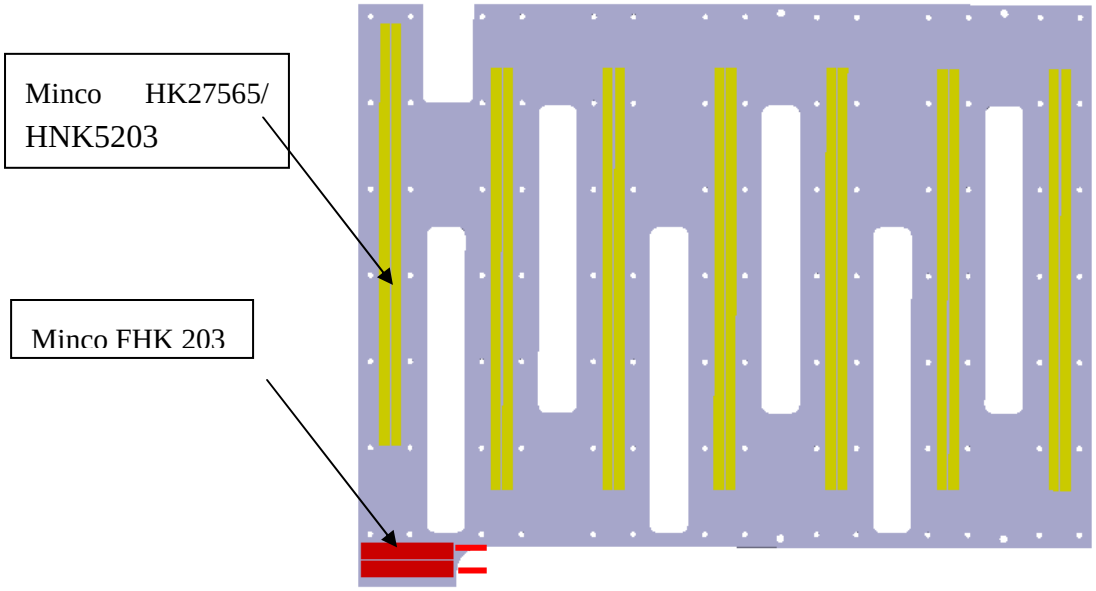


Figura 4-1. .Lead wire direction on the liquid line foil heaters

4.3 Condenser 120 V foil heaters description

The condenser foil heaters are HNK5203R48.4L12B

Size (in) X	Size (in) Y	Size (mm) X	Size (mm) Y	Type	Resistance options- ohms* R(0°C) [May be used with Heaterstat] →				NiFe	Ni	Effective area in² (cm²)	Lead AWG	Insu-lation	Model number
0.25	10.40	6.4	264.2	5	160	80.1	48.4	23.3	24.8	5.7	1.55 (10.00)	26	K, R	5203

Conditioning test per NASA S311-P-079 Table II done at 2.50 W/sq in (13 volts)
PSA 10 backing
With the following custom property:
Lead: 22 AWG wires 12" long minimum

On each condenser, 8 pairs (16 : A+B) heaters will be installed:

- 7 pairs on top plate
- 1 pairs on top strain relief

5 Material and tools required

The following tools are required for this procedure.

a) Power supply
b) Multi-meter; capable of measuring in the 1000 Ohm range or equivalent.
c) Heater ID Label

The materials used for heater installation shall be vacuum compatible. The following material needs to be available during installation:

a) Minco Foil Heater HK27565 with Pressure sensitive adhesive 10
b) Minco foil heaters: FHK 203 with Pressure sensitive adhesive 10
c) Thermocoax wire heaters: ZUZ Ac 15/4cm-336cm-4cm/2xCM15/cement8/2219white/200mm
d) EC 2216 B/A Gray.
e) K-Dry tissues
f) IPA
g) Aluminum tape

NOTE: Use IPA to clean all tools or equipment prior to use in clean room

6 Installation Procedure in main steps

The major steps of installation of the heaters is:

- Inspection of the heater
- Surface preparation
- Heater tape installation
- Electrical check out and record
- Gluing heater tape (only for foil heaters)
- Curing (only for foil heaters)

7 Heater installation procedure

7.1 Heater installation procedure sheets

The installation procedure sheets shall be filled in, and shall accompany foil and wire heaters during their lifetime in order to be able to show the procedure was followed.

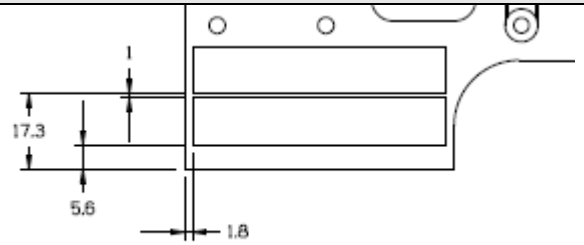
The two foil heaters condenser under the strain relief side will undergo the electrical check out only during the installation of the remaining 7 pair of heaters (final step of the gluing procedure).

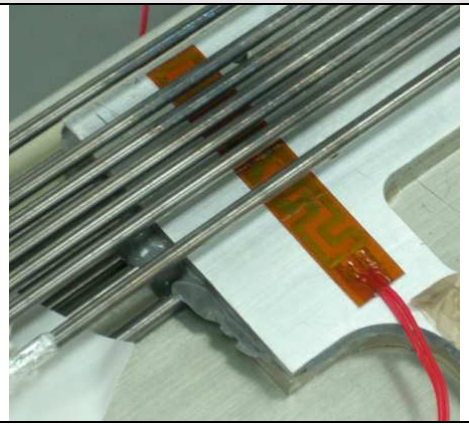
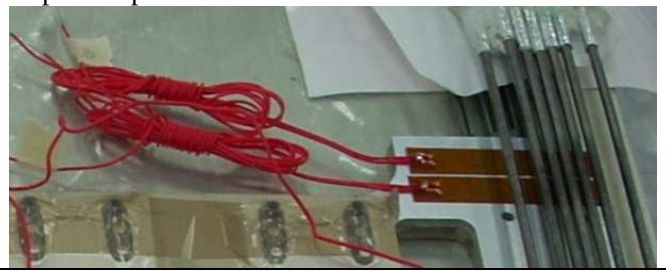
The 4 foil heaters under the strain reliefs will not be spot glued with 3M2216; only the cables of the Minco FK203 will be spot glues, of that heaters, during the last gluing step.

7.2 Liquid line Inlet/outlet foil heater installation procedure sheet

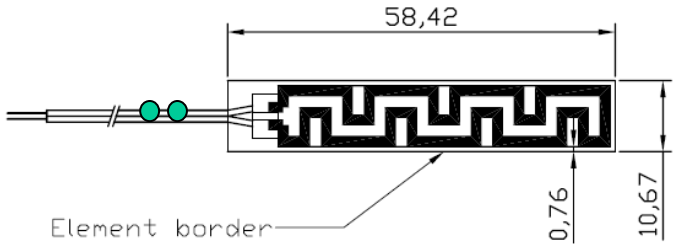
	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record condenser model (P-ram, P-wake, S-ram, S-wake)	T.I. description	-			
2.	Record model (EM / QM / FM)	model	-			
	Visual and electical inspection					
3.	Record test equipment used	manufacturer, type				
4.	Visual inspection on the heaters to be installed		-			
5.	Label the lead wire near the heater that it can be clearly identified when for check. Report in the table (Appendix A) the part number correspondent.	Part number TTCS heater ID	A or B			

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
6.	label the lead wire near the heater that it can be clearly identified when for check. Report in the table (appendix A) the part number correspondent	Part number TTCS heater ID	A or B			
7.	Check the resistance and record	resistance	7.3 Ohm +/- 10%			
	Surface preparation					
8.	Wipe the bonding surface area with K-Dry tissues or equivalent dampened with isopropyl alcohol.					
9.	Determine the required position of the heater and mark reference points with Aluminum tape. Close out all gaps around the edge of heaters					

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
10.	Prepare the location and dimension of MINCO heater according to. Drawing ET5998-09-DR-001-A-KW-CONDENSOR ASSEMBLY or ET5998-10-DR-001-0-KW-CONDENSOR ASSEMBLY (and figure in Appendix A)					
11.	Strip the adhesive backing from the heater and lay the heater on the top plate per the reference drawing and gently press it into place per figure in appendix A					

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
12.	Use a rubber roller (or equivalent tool) to press the heater onto the top plate. Roll from the centre toward the edges.					
13.	Repeats step 12, make sure no trapped air under the heaters.					
14.	Repeat step 11 to 13 for the second heater 					

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
15.	For QM check resistance after gluing per heater individually For FM check resistance after gluing per heater individually		7.3 Ohm +/- 10%	A= B=		
16.	For QM/FM: Power on A & B heater parallel to a **4.2 V** power supply. Rolling while warm and repeat several times 					
	Electric Checkouts and Record					
17.	Record Multimeter used	Type; S/N; cal. Valid date				
18.	Record power supply used	Type; S/N; cal. Valid date				
19.	Check the heaters are electrically isolated with the panel by using Multi-meter.					
20.	For QM/FM: Power on heater A to a **4.2 V** power supply.. Record the voltage and current values of the heater For QM/FM: Power on heater B to a **4.2 V** power supply..	Voltage current	4.2 V 0.57 A	V_A= I_A= Vb=		

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
	Record the voltage and current values of the heater			Ib=		
21.	Recored the derived resistance	Resistance	V/I	RA_{dev}= RB_{dev}=		
22.	Check the derived resistance with the measured one (step 7)	Resistance	From step 7	RA_{mes}= RB_{mes}=		
	Heater tape installation					
23.	Record glue 3M 2216 data and mixing ratio	Expiring date Mixing ratio				
24.	Put glue on the wire leads (3 mm diameter or more, as needed)  NOTE: this wire fixing has to be performed during the final gluing step (together with the installation of all the remaining top plate foil heaters)					

	Inlet/outlet foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
	 (no spot on the edge of the heaters!)					
25.	7 days for fully curing					
26.	End					

7.3 Condenser 120 V foil heater installation procedure sheet

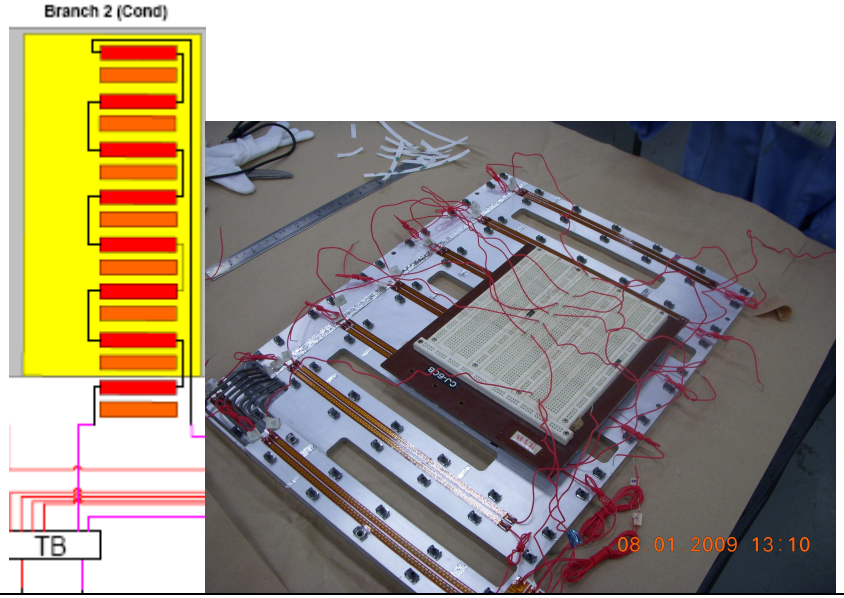
	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record condenser model (P-ram, P-wake, S-ram, S-wake)	T.I. description	-			
2.	Record model (EM / QM / FM)	model	-			
	Visual and electical inspection					
3.	Record test equipment used	manufacturer, type				
4.	Visual inspection on the heaters to be installed		-			
5.	Label the lead wire near the heater that it can be clearly identified when for check. Report in the table on appendix A the part number correspondent.	Part number TTCS heater ID	A or B			
6.	label the lead wire near the heater that it can be clearly identified when for check. Report in the table on appendix A the part number correspondent	Part number TTCS heater ID	A or B			
7.	Repeat step 5 and 6for the remaining pairs of heaters					
8.	Check the resistance and record (in table in Appendix A)	resistance	48.4 Ohm +/- 10%			

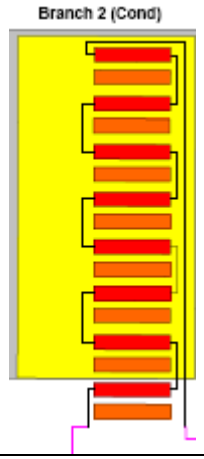
	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
	Surface preparation					
9.	Wipe the bonding surface area with K-Dry tissues or equivalent dampened with isopropyl alcohol.					
10.	Determine the required position of the heater and mark reference points with Aluminum tape. Close out all gaps around the edge of heaters					

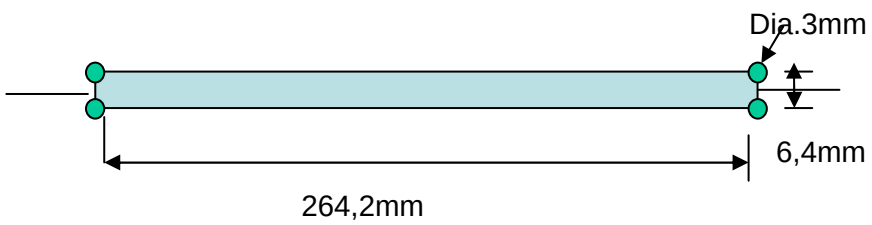
	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
11.	Prepare the location and dimension of MINCO heater according to Appendix B and drawing ET5998-09-DR-001-A-KW-CONDENSOR ASSEMBLY or ET5998-10-DR-001-0-KW-CONDENSOR ASSEMBLY (figure in Appendix A)					
12.	Strip the adhesive backing from the heater and lay the heater on the top plate per the reference drawing and gently press it into place per figure in appendix A					

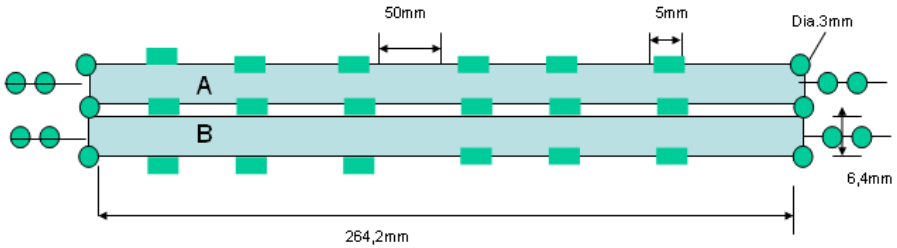
	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
13.	Use a rubber roller (or equivalent tool) to press the heater onto the top plate. Roll from the centre toward the edges. 					
14.	Repeats step 13, make sure no trapped air under the heaters.					
15.	For QM/FM: Power on A heater parallel to a **50 V** power supply. Rolling while warm and repeat several times					

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
16.	Repeat step15 for heaters B					
	Electric Checkouts and Record					
17.	Record Multimeter used	Type; S/N; cal. Valid date				
18.	Record power supply used	Type; S/N; cal. Valid date				
19.	Check the heaters are electrically isolated by using Multi-meter.					
20.	Connect all heaters A in series(red), using a bread-board					

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
						
21.	For QM/FM: Power on heaters A to a **<u>50 V</u>** power supply.. Record the voltage and current values of the heater group 	Voltage current		Va Ia		

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
22.	Check the derived resistance with the measured one for heaters A(step8)	Resistance	Design: 8*48,4=387,2Ohm From step 8(measured): 8*R_{step8}= Ohm	**Derived Resistance (V/A)(Ω)** **Ra=**		
23.	Connect all heater B in series (orange) 					
24.	For QM/FM: Power on heaters B to a **50 V** power supply. Record the voltage and current values of the heaters	Voltage current		Vb= Ib=		

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
25.	Check the derived resistance with the measured one for heaters B(step8)	Resistance	Design: 8*48,4=387,2Ohm From step 8: 8*R_{step8}= Ohm	**Derived Resistance (V/A)(Ω) Rb=**		
	Heater Tape Installation					
26.	Record glue 3M 2216 data and mixing ratio	Expiring date Mixing ratio				
27.	Put 4 spots of glue on the heater patch corners (3 mm diameter) **(DON'T SPOT GLUE THE HEATERS UNDER STRAIN RELIEF SIDE)**  					

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
28.	Put glue on the wire leads (3 mm diameter or more, as needed) 					
29.	Put glue on the edges : every 50 mm put a spot of glue of this size: 2 to 3 mm wide (i.e.: across the edge), enough to bridge the heater and the surface underneath 5 mm long (i.e.: along the edge) **(DON'T SPOT GLUE THE HEATERS UNDER STRAIN RELIEF SIDE)** 					
30.	Repeat step 26 to 29 for all the remaining heaters.					

	Condenser 120 V foil heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
31.	7 days for fully curing					
32.	End					

7.4 Wire heater installation procedure sheet

	Wire heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record condenser model (P-ram, P-wake, S-ram, S-wake)					
2.	Verify condenser tube brackets are mounted and positioned in correct place					
3.	Record lock wire used				Cessna Aircr. comp. B08/026	
4.	Visual inspection on the 2 heaters to be installed	Part number				
5.	Label the lead wires of each heater HTR_A and HTR_B.					
6.	Check the resistances and record resistance wire heater and insulation resistance	Resistance heater Insulation	49 ohm > 1 Mohm	. . . .		
7.	Check the length between connectors and record	cm	336 cm	. .		
8.	Create ‘fit-wire’ with correct length					
9.	Bend ‘fit-wire’ in the middle, using 10 mm OD tube					

	Wire heater installation procedure		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
10.	Wrap 'fit-wire' around condenser tube according to drawing ET5998-09-DR-001-B-KW-CONDENSOR ASSEMBLY 20081118					
11.	Remind bend radius R > 3 mm, do not twist / kink wire					
12.	Take pictures, record typical values like threads between brackets, number of bends etc.					
13.	Bend wire heaters in the middle, using 10 mm OD tube					
14.	Wrap 'fit-wire' around condenser tube according to drawing ET5998-09-DR-001-B-KW-CONDENSOR ASSEMBLY 20081118 and results obtained in previous steps					
	Fasten wire heater with lock wire 0.032''					
15.	Fasten connectors on 4 mm tubes with ty-raps					
16.	Check the resistances and record resistance wire heater and insulation resistance	Resistance heater Insulation	49 ohm > 1 Mohm			
17.	Take pictures of result.					
18.	End					

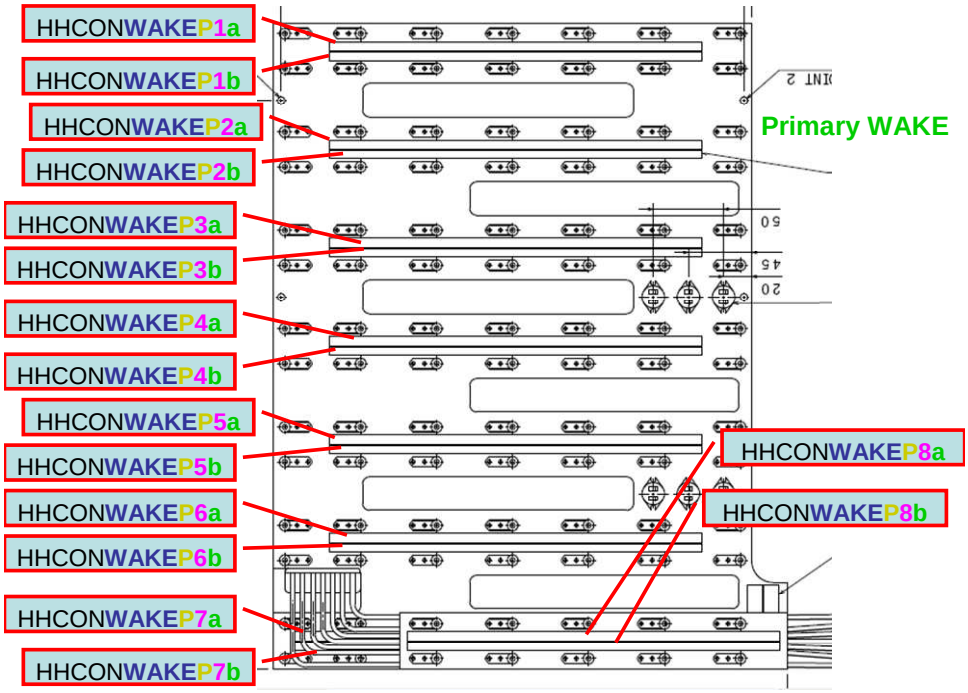
8 Appendix A

In the following tables are described the correspondence between the ID heater on TTCS loop are related to the heater P/N provided by the supplier:

Location/	Condenser	ID heater	P/N
Inlet/outlet foil heater	QM	HHLL1aPW_f	
		HHLL1bPW_f	
	PW	HHLL**1aPWAK_f**	
		HHLL**1bPWAK_f**	
	SR	HHLL**1aSRAM_f**	
		HHLL**1bSRAM_f**	
	PR	HHLL**1aPRAM_f**	
		HHLL**1bPRAM_f**	
	SW	HHLL**1aSWAK_f**	
		HHLL**1bSWAK_f**	
Condenser foil heater	QM	HHCON**WP7a**	
		HHCON**WP7b**	
	PW	HHCON**WAKEP1a**	
		HHCON**WAKEP1b**	
		HHCONWAKEP2a	
		HHCONWAKEP2b	
		HHCONWAKEP3a	
		HHCONWAKEP3b	
		HHCONWAKEP4a	
		HHCONWAKEP5a	
		HHCONWAKEP5b	
		HHCONWAKEP6a	
		HHCONWAKEP6b	
		HHCONWAKEP7a	
		HHCONWAKEP7b	
		HHCONWAKEP8b	
		HHCONWAKEP8a	

SR	HHCON**RAMS1a**
	HHCON**RAMS1b**
	HHCONRAMS2a
	HHCONRAMS2b
	HHCONRAMS3a
	HHCONRAMS3b
	HHCONRAMS4a
	HHCONRAMS5a
	HHCONRAMS5b
	HHCONRAMS6a
	HHCONRAMS6b
	HHCONRAMS7a
	HHCONRAMS7b
	HHCONRAMS8b
	HHCONRAMS8a
PR	HHCON**RAMP1a**
	HHCON**RAMP1b**
	HHCONRAMP2a
	HHCONRAMP2b
	HHCONRAMP3a
	HHCONRAMP3b
	HHCONRAMP4a
	HHCONRAMP5a
	HHCONRAMP5b
	HHCONRAMP6a
	HHCONRAMP6b
	HHCONRAMP7a
	HHCONRAMP7b
	HHCONRAMP8b
	HHCONRAMP8a
SW	HHCON**WAKES1a**
	HHCON**WAKES1b**
	HHCONWAKES2a
	HHCONWAKES2b
	HHCONWAKES3a

		HHCONWAKES3b
		HHCONWAKES4a
		HHCONWAKES5a
		HHCONWAKES5b
		HHCONWAKES6a
		HHCONWAKES6b
		HHCONWAKES7a
		HHCONWAKES7b
		HHCONWAKES8b
		HHCONWAKES8a
Liquid line wire heater	QM	HHLL1aPW_w HHLL1bPW_w
	PW	HHLL**1aPWAK_w** HHLL**1bPWAK_w**
	SR	HHLL**1aSRAM_w** HHLL**1bSRAM_w**
	PR	HHLL**1aPRAM_w** HHLL**1bPRAM_w**
	SW	HHLL**1aSWAK_w** HHLL**1bSWAK_w**


HHCONWAKEP1a
HHCONWAKEP1b
HHCONWAKEP2a
HHCONWAKEP2b
HHCONWAKEP3a
HHCONWAKEP3b
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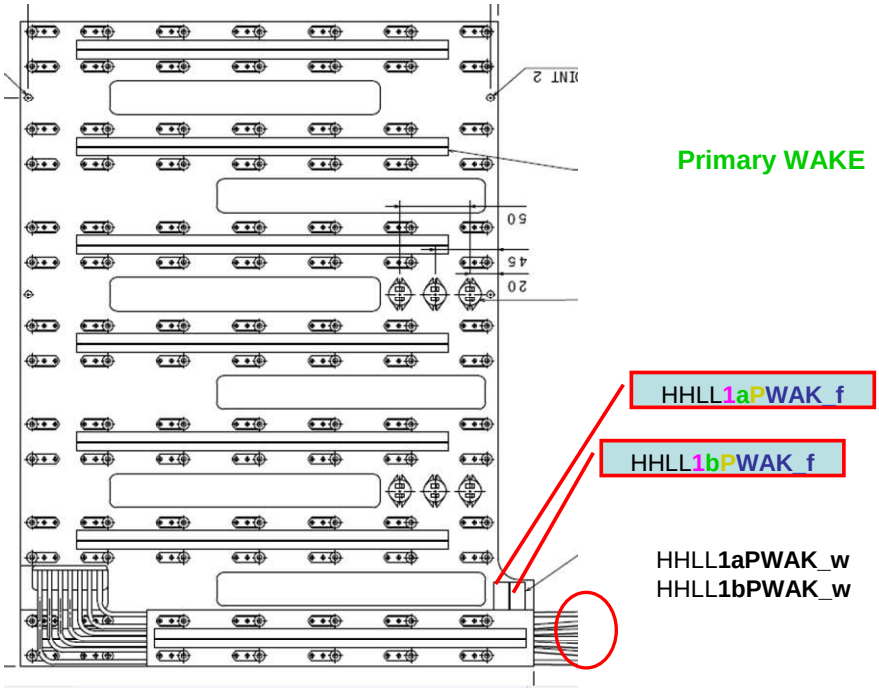
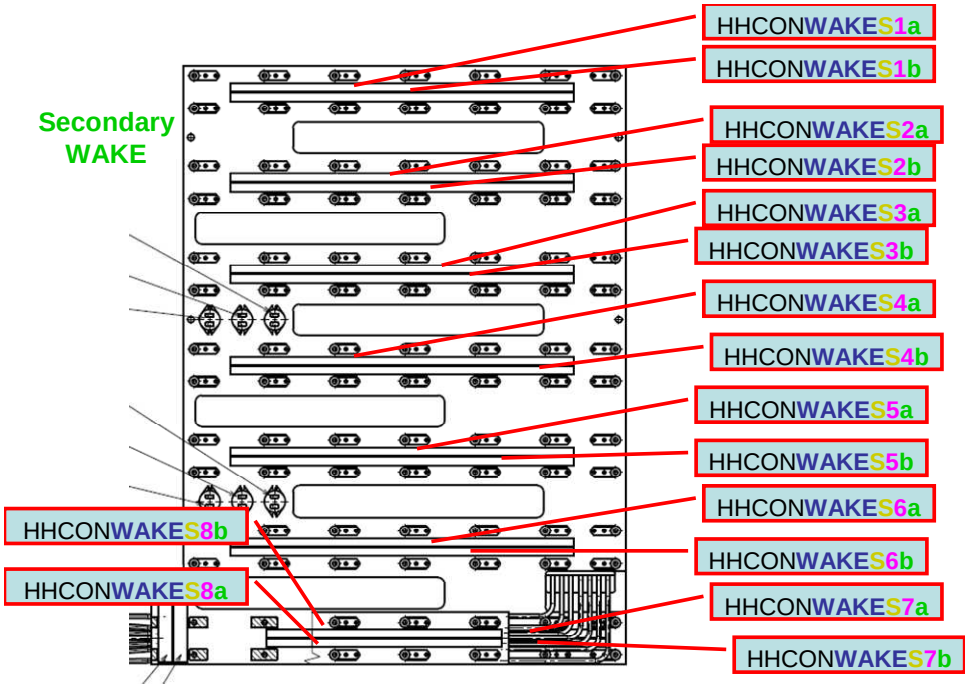
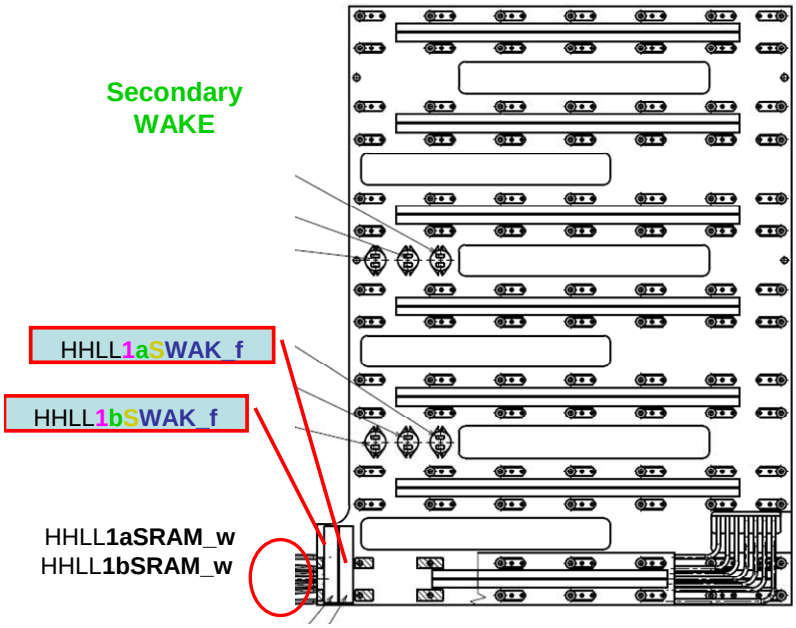
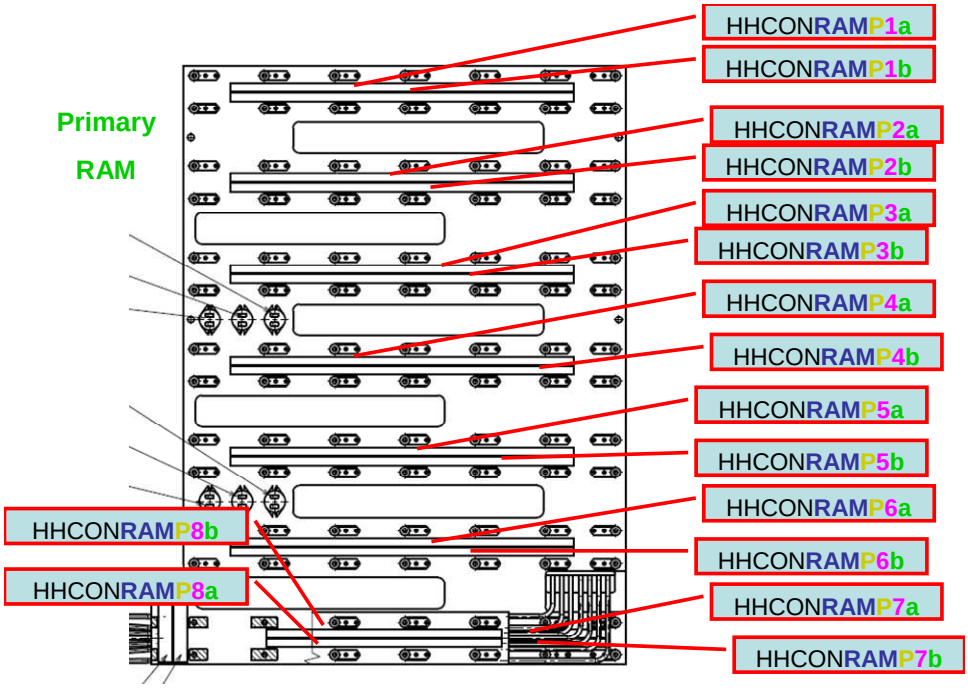
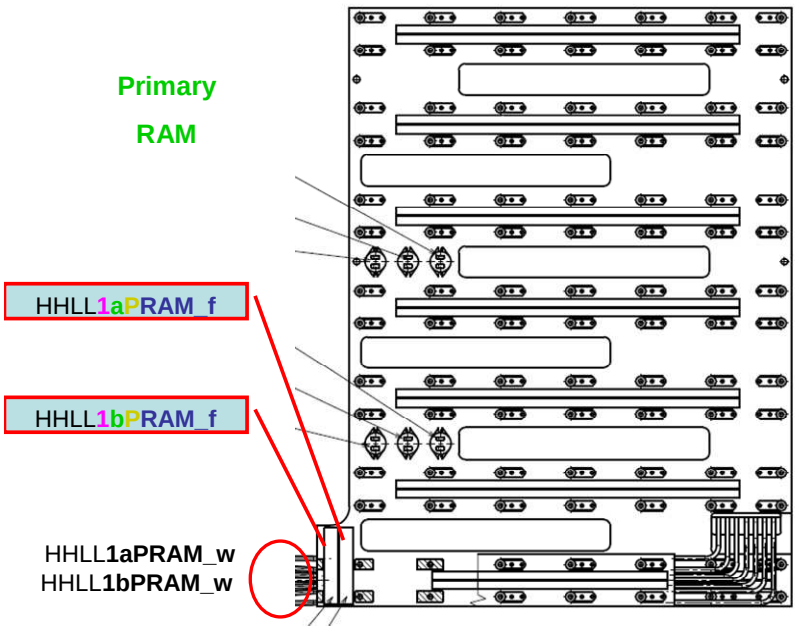
HHCONWAKEP4b
HHCONWAKEP5a
HHCONWAKEP5b
HHCONWAKEP6a
HHCONWAKEP6b
HHCONWAKEP7a
HHCONWAKEP7b
Primary WAKE
HHCONWAKEP8a
HHCONWAKEP8b

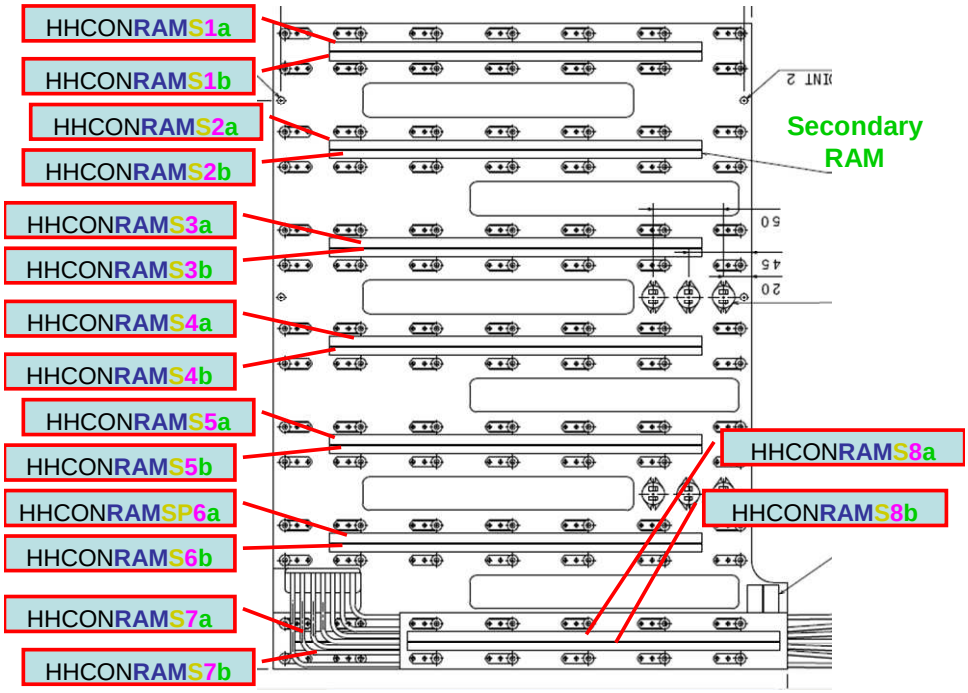

Primary WAKE
HHLL1aPWAK_f
HHLL1bPWAK_f
HHLL1aPWAK_w
HHLL1bPWAK_w

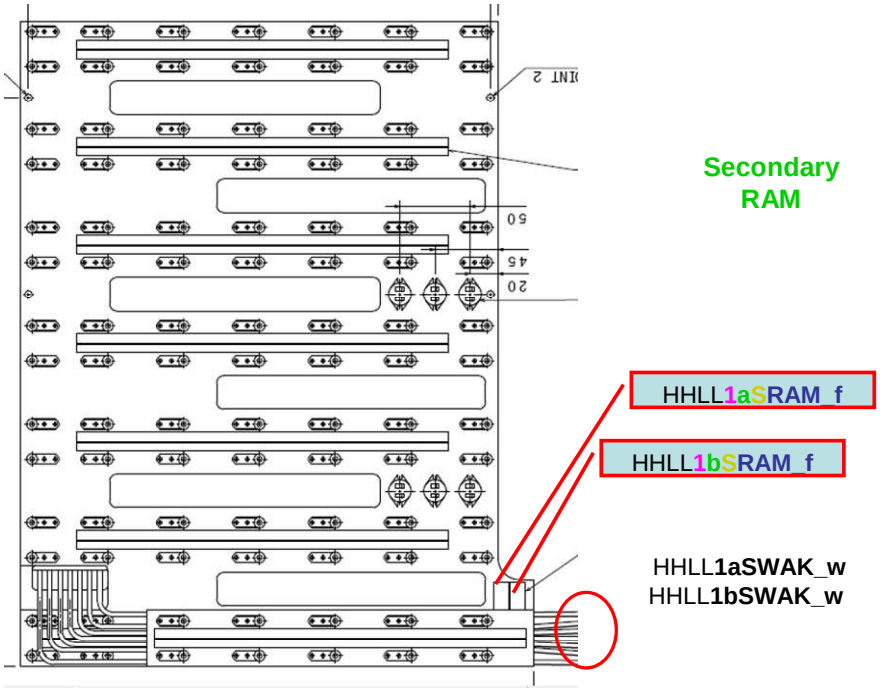

Secondary WAKE
HHCONWAKES1a
HHCONWAKES1b
HHCONWAKES2a
HHCONWAKES2b
HHCONWAKES3a
HHCONWAKES3b
HHCONWAKES4a
HHCONWAKES4b
HHCONWAKES5a
HHCONWAKES5b
HHCONWAKES6a
HHCONWAKES6b
HHCONWAKES7a
HHCONWAKES7b
HHCONWAKES8b
HHCONWAKES8a


Secondary WAKE
HHLL1aSWAK_f
HHLL1bSWAK_f
HHLL1aSRAM_w
HHLL1bSRAM_w


Primary
RAM
HHCONRAMP1a
HHCONRAMP1b
HHCONRAMP2a
HHCONRAMP2b
HHCONRAMP3a
HHCONRAMP3b
HHCONRAMP4a
HHCONRAMP4b
HHCONRAMP5a
HHCONRAMP5b
HHCONRAMP6a
HHCONRAMP6b
HHCONRAMP7a
HHCONRAMP7b
HHCONRAMP8b
HHCONRAMP8a

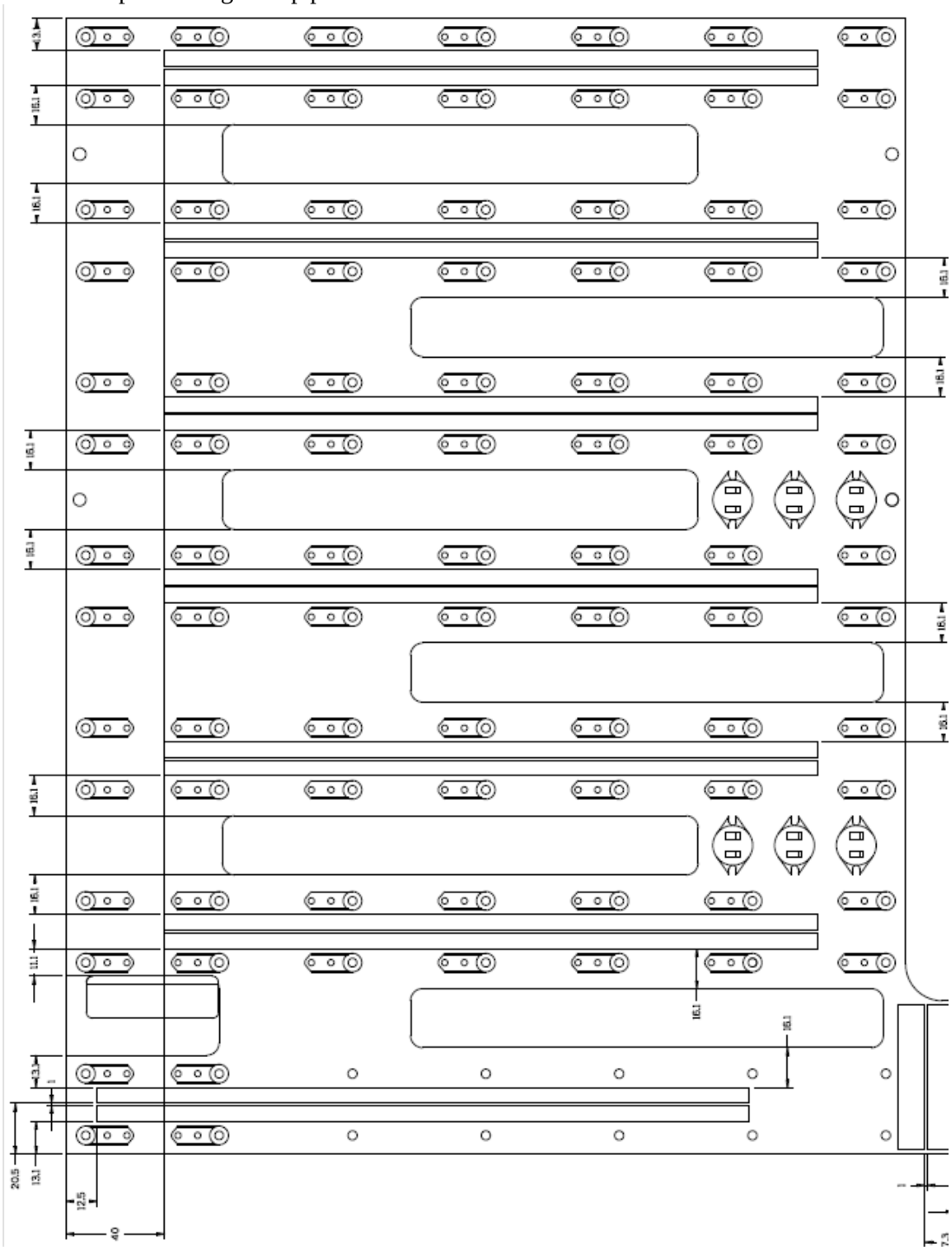

Primary
RAM
HHLL1aPRAM_f
HHLL1bPRAM_f
HHLL1aPRAM_w
HHLL1bPRAM_w

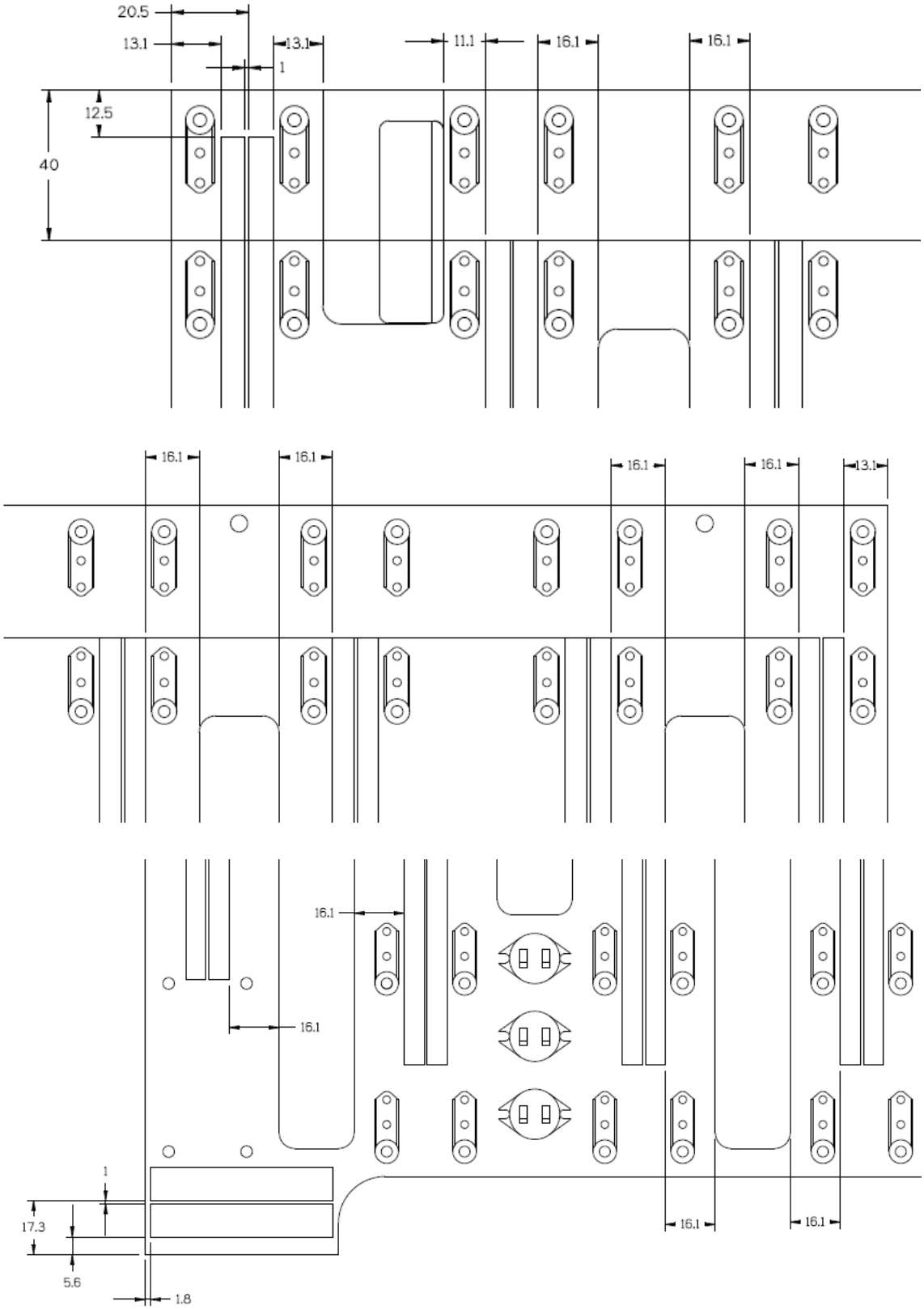

HHCONRAMS1a
HHCONRAMS1b
HHCONRAMS2a
HHCONRAMS2b
HHCONRAMS3a
HHCONRAMS3b
HHCONRAMS4a
HHCONRAMS4b
HHCONRAMS5a
HHCONRAMS5b
HHCONRAMSP6a
HHCONRAMS6b
HHCONRAMS7a
HHCONRAMS7b
HHCONRAMS8a
HHCONRAMS8b
Secondary RAM


Secondary RAM
HHLL1aSRAM_f
HHLL1bSRAM_f
HHLL1aSWAK_w
HHLL1bSWAK_w

9 Appendix B

Foil heater positioning on top plate




20.5
13.1
13.1
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11.1
16.1
16.1
12.5
40
16.1
16.1
16.1
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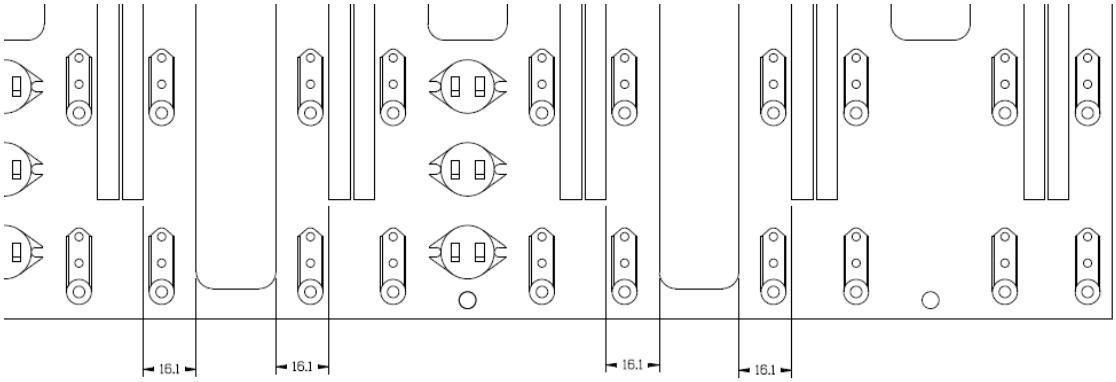
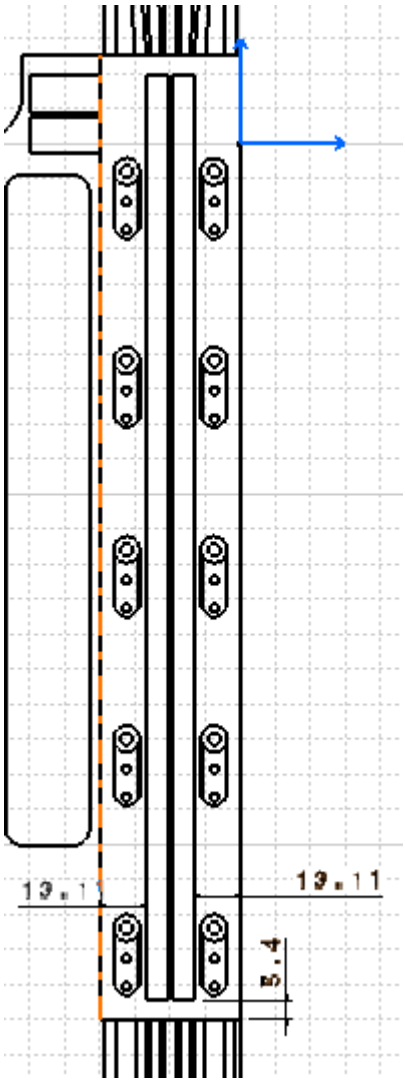
1
17.3
5.6
1.8
16.1
16.1



Foil heater positioning on top strain relief



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